Simulating response of canola to sowing date in Western Australia

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ABSTRACT

Canola yields decrease with delay in sowing date in Western Australian environments. Data from field experiments, conducted in 1997 and 1998 with different cultivars and sowing dates in several locations in Western Australia, were used to calibrate and test the APSIM-Canola model. The wide range of observed flowering dates were predicted by the model with a RMSD of 5.0 days. The period from sowing to flowering decreased with the delay in sowing date. The model predicted yields with a RMSD of 0.4 t ha^{-1}. The yield reduction with delayed sowing date ranged from 3.3% per week in Mt Barker (high rainfall) to 10.1% per week in Mullewa (low rainfall), which was also reproduced by the model. The APSIM-Canola model, together with long-term weather data, can be used to optimise combinations of cultivar x location x sowing date in the highly variable rainfall environment of Western Australia. Further development and testing is required to account for seed oil content.

KEY WORDS

Canola, phenology, yield, sowing date, simulation model.

INTRODUCTION

Canola (*Brassica napus* L.) has become a major crop in Western Australian agriculture, increasing in area from 100,000 ha in 1995 to 900,000 ha in 1999. As canola is still a new crop for Western Australia, there is the need to define optimum sowing dates for different cultivars, locations and farming systems. Sowing date is an important determinant of yield in canola. Decreasing yields with delayed sowing date have been reported in previous studies (2, 3, 5). Relative yield loss from 4.2 to 10.8% per week delayed in sowing has been found in published studies (3). Sowing date depends on the onset of significant rainfall in autumn, and therefore, in the Western Australian Mediterranean-type environment, it varies considerably from year to year. In such an environment, a large number of experiments would be required to optimise sowing dates and cultivars. Crop simulation models, once calibrated and tested, offer a powerful tool to study crop systems by minimising the number of experiments required. Prediction of phenology and yield are key issues in those conditions. The APSIM-Canola model has been tested in different environments in eastern Australia (3) but not in Western Australia.

The aim of this paper is (i) to calibrate and test the simulation of flowering date in the APSIM-Canola model; and (ii) to test the predictive ability of the APSIM-canola model for yield at different sowing dates in Western Australia.

MATERIALS AND METHODS

The data from field experiments, conducted in five locations in Western Australia in 1997 and 1998 (G. H. Walton, unpublished), were used to calibrate and test the APSIM-Canola model (version 1.60) (Table?1). The 1997 experiment was used for model calibration and the 1998 experiment for model testing.

Experimental data

In 1997 and 1998 experiments were conducted at different locations, with a range of cultivars and sowing dates (Table 1). Locations ranged from 200 to 600 mm seasonal rainfall in the years of the experiments. Soil types were duplex and loamy sands. For each soil type, soil characteristics were taken from Asseng *et al*. (1). Cultivars comprised a wide range of maturity types, from early to late maturing. The experiments were under dryland conditions with sowing depth of 2 cm and row spacing of 18 cm. Crops were supplied with 30 to 80 kg N ha^{-1}. Crop emergence occurred a few days after sowing with an estimated plant density of 60-80 plants m^{-2}. Weeds were controlled chemically. Disease incidents were recorded when occurred. Flowering dates (taken when 50% of the plants had first flower) were recorded. At maturity, grain yield and shoot biomass were measured in three replications.

Table 1. Datasets used to calibrate and to test the APSIM-Canola model.

Location			Soil type	Cultivars[1]	Sowing dates[2]	Season rainfall (Apr-Oct)
Site	Latitude	Longitude				
			Year 1997 – Model calibration			
Mullewa	-28.5	115.5	Red duplex	M,H,K,O, D	122,139,154, 167	317
Wongan Hills	-30.8	116.7	Loamy sand	M,H,K,O, D	151,168,181,192	256
Hines Hill	-31.5	118.1	Loamy sand	M,H,K,O, D	146,160,174	221
Lake Grace	-33.1	118.5	Yellow duplex	M,H,K,O, D	113,142,154, 168	265
Mt Barker	-34.6	117.7	Loamy sand	H,K,O,G,P,Du	128,150,175, 195	460
			Year 1998 – Model testing			
Mullewa	-28.5	115.5	Red duplex	K,M	128,147,155,173	292
Wongan Hills	-30.8	116.7	Loamy sand	K,M,O	112,142,170	320
Mt Barker	-34.6	117.7	Loamy sand	K,O,P,R	104,138,175	600

[1] M: Monty; H: Hyola 42; K: Karoo; O: Oscar; D: Drum; G: Grouse; P: Pinnacle; Du: Dunkeld; R: Range
[2] Expressed in day of year

APSIM-Canola model

The APSIM-Canola model (4) simulates crop development (phenology), growth, yield and nitrogen uptake in response to temperature, photoperiod, radiation, soil water and nitrogen supply. The model uses a daily time-step and is driven by daily weather inputs. Crop development is simulated in phases, using parameters, which are specific to each cultivar. The period from sowing to flowering is simulated in four phases, and their durations are determined by temperature, vernalisation and photoperiod (4). The duration from flowering to physiological maturity is based on temperature only. Leaf area expansion is driven by temperature and limited by water and nitrogen stresses. Biomass is accumulated using a radiation use efficiency approach, and partitioned among organs in fractions that vary with stage of development. Yield accumulation is simulated using a daily harvest index (HI) increase approach.

RESULTS AND DISCUSSION

Model calibration of phenology

The cultivar-specific parameters for phenology were derived from the literature and then optimised for the best prediction of the observed flowering dates in the 1997 experiment. Flowering dates for the 1997 experiment, from which the parameters were derived, were predicted by the model with a Root Mean Square Deviation (RMSD) of 6.4 days (n = 99).

Model testing

An independent testing of the model performance was carried out for flowering date and grain yield using the 1998 experiment. Flowering dates were predicted with a RMSD of 5.0 days (n = 28) for a wide range of locations, cultivars and sowing dates in Western Australia (Fig. 1a). Fig. 2 shows the observed and simulated flowering dates, for different sowing dates, for two contrasting locations and two cultivars. The model reproduced the observed reduction in the period from sowing to flowering with the delay in sowing time (Fig. 2). Robertson *et al*. (3) found a similar trend of decrease in the duration from sowing to flowering with delayed sowing dates in other regions of Australia. Grain yields ranged from 0.5 to 3.9t ha^{-1} in the 1998 experiment. The model, satisfactorily predicted the wide range of observed grain yields, with a RMSD of 0.4 t ha^{-1} (n = 31) for different cultivars and sowing dates in three locations in 1998 (Fig. 1b). However, grain yields were generally underestimated in Mullewa and overestimated in Mt Barker (Fig. 1b).

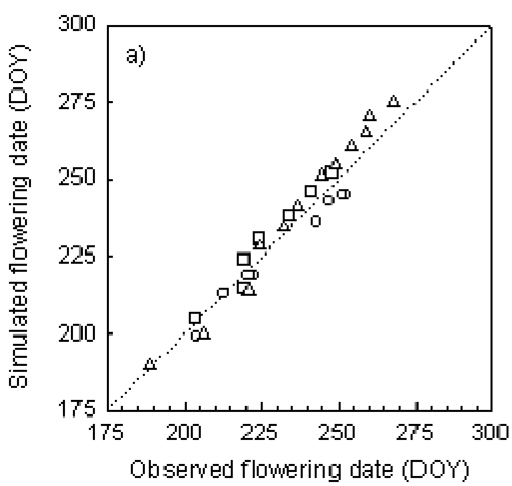

Figure 1. Simulated versus observed (a) flowering dates and (b) yields for different canola cultivars at Mt?Barker (○), Mullewa (□) and Wongan Hills (△) in the 1998 experiment. The dotted line is the 1:1 line. DOY, day of the year.

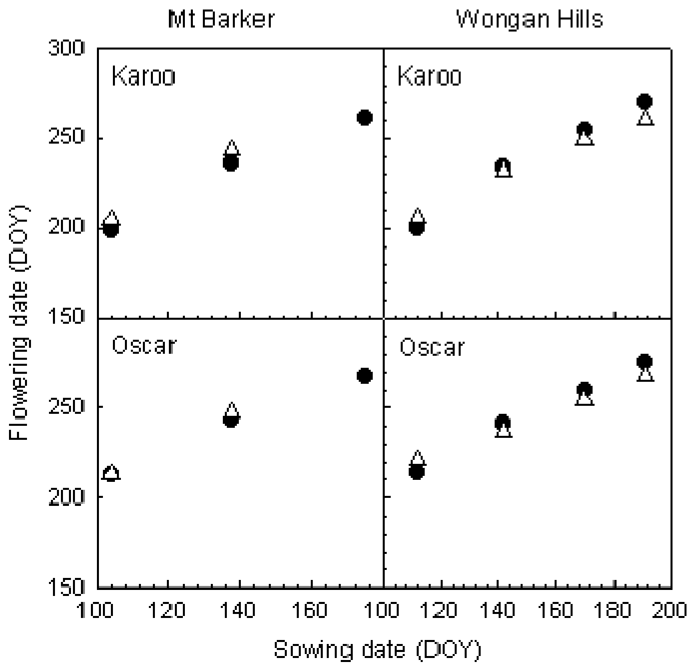

Figure 2. Simulated (●) and observed (Δ) canola flowering dates at Mt?Barker and Wongan Hills with cultivars Karoo and Oscar for different sowing dates in 1998. Note, observed flowering dates at Mt Barker in late sowing were not available.

The model predicted the general observed yield decline as a response to sowing date (Fig. 3). The response to sowing date was partly a function of crop phenology (shorter growth duration with late sowing) and partly due to the occurrence of a more severe water deficit during grain filling with late sowing. This is supported by the greater decline in yield with delayed sowing in a lower rainfall location (Wongan Hills) as compared to the less marked yield decline in a higher rainfall location (Mt Barker) (Fig. 3). The relative yield reduction with delayed sowing dates ranged from 3.3% per week delay in Mt Barker to 5.7% per week delay in Wongan Hills and 10.1% per week delay in Mullewa, which were also reproduced by the model (3.2, 6.2 and 10.7% per week, respectively). The average yield reduction in the 1998 experiment (5.9% per week) was similar to the mean of 5.1% per week from several published Australian studies (3). Apart from a decline in yield, delay in sowing date has a negative effect on oil contents (6), and oil content together with grain yield are important components of crop profitability. However, oil content is currently not considered in the model.

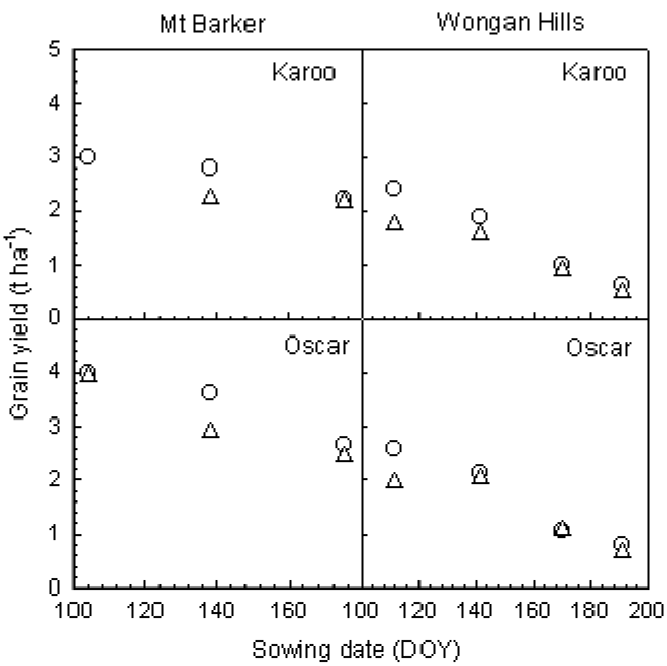

Figure 3. Simulated (●) and observed (Δ) grain yield at Mt Barker and Wongan Hills with cultivars Karoo and Oscar for different sowing dates in 1998. Note, observed yield for Karoo at Mt Barker in first sowing date was not available due to blackleg disease.

CONCLUSIONS

The APSIM-Canola model satisfactorily predicted the observed yield decline with a delay in sowing date for a wide range of locations and cultivars in Western Australia. The model, together with long-term weather data, can be used as a tool to optimise yields for combinations of cultivar x location x sowing date. However, more work is required for development and testing of an oil content routine in the model.

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